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CLARKSON BULLETIN

OCTOBER NUMBER

1916

POTSDAM, N. Y.

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Bulletin

of

Clarkson College of Technology

The Thomas S. Clarkson Memorial

Chartered by the Regents of
THE UNIVERSITY OF THE STATE OF NEW YORK
March, 1896—September, 1913

POTSDAM, N. Y.

ISSUED QUARTERLY BY
THOMAS S. CLARKSON MEMORIAL COLLEGE OF TECHNOLOGY

Entered January 16, 1904, at Potsdam, N. Y.,
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1916

CLARKSON BULLETIN

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George Spencer Lobdell, B. S.
Instructor in Chemistry

Announcements

CLARKSON TECH BANQUET

NEW YORK CITY

Satu day Night, January twentieth

1917

Basket Ball Schedule—1916-17

At home:

Saint Michaels College... ... ...Dec. 7
N. Y. State Teachers College.. ... ...Jan. 12
Brooklyn Polytechnic Institute... ... ...Jan. 27
Boston University (possibly)... ... ...Feb. 9
Hobart College... ... ... .Feb. 17
College of City of New York... ... ... .Feb. 23
Buffalo University... ... ...Feb. 27

Abroad:

Union University at Schenectady... ... ...Dec. 14
Syracuse University at Syracuse... ... ...Dec. 15
Colgate University at Hamilton... ... ...Dec. 16
New York University (possibly) at New York.....Jan. 18
Brooklyn Polytechnic Insti. (possibly) at Brooklyn Jan. 19
Seaton Hall (possibly) at Orange, N. J.... ... ..Jan. 20

Foot Ball—1916

Four games were played. Clarkson defeated Rensselaer Polytechnic Institute at Troy and Saint Michaels at home. Clarkson was defeated by University of Vermont at Burlington and by University of Rochester at Rochester.

Addresses of Class of 1916

Wm. C. Bassette, State Highway Dept.

Lynn N. Bedford. General Electric Co., Schenectady, N. Y.; mail, 205 Seward Place.

C. I. Blair, McFarland Automobile Co., Connersville, Ind.

Edgar V. Cayey, Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.; mail, 734 Wallace Ave., Wilkinsburg, Pa.

Philip R. Cloke, Graduate student, Clarkson College.

Manuel W. Dans, General Electric Co., Schenectady, N. Y.

J. Houston Duffy, Cattaraugus Tanning Co., Olean, N. Y.

Floyd J. Dutcher, American Bridge Co., Elmira, N. Y.; mail, 419 West First St.

Beach B. Fairman, Toledo Gas & Electric Co., Toledo, Ohio.

Floyd H. Fish, Robert Gair Co., Brooklyn, N. Y.; mail, 27 Munroe Place.

W. B. Gero, Westinghouse Lamp Co., Bloomfield, N. J.; mail, 240 Prospect Place, East Orange, N. J.

Archie B. Gibson, Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.; mail, 1110 Center St., Wilkinsburg, Pa.

Harry N. Gray, State Highway Dept., Buffalo Office.

Roy F. Hayes, H. H. Franklin Mfg. Co., Syracuse, N. Y.

Joseph H. Hayes, Toledeo Gas & Elec. Co., Toledo, Ohio.

Norman M. Hulings, Harrison Boiler Works, Philadelphia, Pa.; mail, 916 Sweede St., Norristown, Pa.

Lesley Kelsey, H. H. Franklin Mfg. Co., Syracuse, N. Y.

Joseph W. Lancto, General Electric Co., Lynn, Mass.; mail, 92 South Common St.

George S. Lobdell, Instructor in Chemistry, Clarkson College.

Felix F. McCue, General Electric Co., Schenectady, N. Y.

Harold A. Maine, General Elec. Co., Lynn, Mass.; mail, 24 Baker St.

Cornelius F. Maley, N. Y. C. R. R. Co., Oswego, N. Y.; mail, 127 West 7th St.

Keith W. Morrison, Chalmers Motor Co., Detroit, Mich.

Howard H. Needham, American Bridge Co., Gary, Ind.

Luther E. Olson, St. Lawrence Transmission Co., Potsdam, N. Y.

Earl L. Pelton, Holland Aniline Co., Holland, Mich.

Byron C. Perkins, Chicago Edison Co., Chicago, Ill.; mail, 1547 Jackson Boulevard.

Paul R. Pierson, Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.

George H. Randall, American Bridge Co., Elmira, N. Y.

Blythe M. Reynolds, General Chemical Co., Brooklyn, N. Y.; mail, 673 Washington St., Easton, Pa.

Howard M. Smith, Graduate student, Clarkson College.

Frank Van Voorhis, Jr., General Electric Co., Schenectady, N. Y.; mail, 205 Seward Place.

Andrew S. Warwick, United Natural Gas Co., Oil City, Pa.; mail, 308 Seneca St.

Arthur O. West, N. Y. C. R. R., Buffalo, N. Y.

Fred B. Wilcox, Remington Arms Co., Bridgeport, Conn.

Some Hydraulic Analogies to Electric Phenomena

By Alfred Raymond Powers.*
and William Allen Dart.**

Every one who has studied electricity and magnetism knows from experience that it is extremely difficult to start the imagination toward the conception of electrical phenomena. It is probaly true that no subjects are harder on the student mind than those just mentioned.

Several methods have been tried in attempting to find easy introductions to these subjects. Dr. W. S. Franklin has for several years been using combinations of weights and springs as analogous to electric and magnetic circuits. While these analogies are undoubtedly mathematically correct, the student in general finds them unreal from a physical standpoint. But the method of teaching pure theory without an appeal to physical concepts is liable to lead to a "parrot" knowledge which seems to be of questionable value. Many of the hydraulic analogies are not sufficiently similar to electrical phenomena. The authors therefore wish to submit to the reader the following analogies with a hope that he may find physical ideas which will help in the study of fundamental principles.

Let us take the terms of hydraulic measurements and apply them to the electric system of units.

(1) Pressure; lbs. per sq. in.

May we not say that pressure is the work in foot pounds required to raise 1-2.3 lbs. of water from a position of no work to a height of h ft.

(1a) Potential; volts.

This is the work done upon a certain weight of electricity in carrying it from infinity, or position of no work, to a point.

(2) Current; cu. ft. per sec.

It is the rate of passage quantity.

(2a) Current; amperes.

It is also the rate of passage of quantity.

(3) Quantity; Cu. ft, is self explanatory.

(3a) Quantity; coulombs, is also self explanatory.

(4) Power.

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*Professor of Electrical Engineering, Clarkson College of Technology.

**Instructor of Engineering, Clarkson College.

We know that Wh equals energy expended in raising a weight of W pounds through a height h,

hence $\frac{W}{t}h$ = rate of expenditure of energy

but $\frac{W}{t} = \frac{Wt}{sec}$ or $\frac{Q\ 62.5}{t} = q\ 62.5$ where q = cu. ft. ÷ sec.

but $h = 2.3 \times p$ where p = lb ÷ sq. in.

hence $2.3 \times 62.5 \times p \times q$ = power

or if the units are properly chosen

$$p. \times q. = \text{power}.$$

(4a) We may then infer that pressure x quantity per sec. is a measure of Power, or in the electric circuit

$$EI = \text{Power}.$$

From the preceding we may conclude that we have no new phenomena to deal with in the simple measurements.

Let us now turn our attention to a case of statics in electricity. The simple condenser is two plates of metal separated by a dielectric. It has been proven by experiment that a condenser is a device by which energy is stored. It is also true, determined by experiment as well as theory, that the quantity of electricity stored in a condenser is proportional to the voltage and the capacity. Other known conditions are; that the energy storage is in the dielectric of the condenser and is measured

as $\frac{CE^2}{2}$

C = capacity
E = voltage

that the capacity is $C = \frac{KA}{t}$ where

K = a constant dependent upon the nature of the dielectric and the units used.
A = area of the dielectric
t = thickness of the dielectric.

In the hydraulic system if a diaphragm be placed on a flange at the end of a pipe it is an hydraulic condenser. For, the quantity of water which will be stored in this apparatus will be directly proportional to the pressure (within reasonable limits). Not only this, but the energy will be stored in the dielectric or the diaphragm. Then, too, the capacity or the quantity per unit of pressure will be directly proportional to the area of the diaphragm, inversely proportional to its thickness and to some constant depending upon the material. It may also be proven that the energy stored is,

$$W = \frac{Kp^2}{2} \quad \text{or} \quad \frac{CE^2}{2}$$

Following the study a step further we find that by connecting several condensers in series whether they be electric or hydraulic the

same laws hold. It will be seen that when pressure is applied at the first diaphragm it is distended and forces water into the second condenser. A slight amount of study will show that the pressure difference for each condenser is inversely proportional to its capacity. From this it follows that

$$q = c\,p = c_1\,p_1 = c_2\,p_2$$

or $$\frac{q}{c} = p \qquad \frac{q}{c_1} = p_1 \qquad \frac{q}{c_2} = p_2$$

but $$p + p_1 + p_2 = P$$

where c, c_1, and c_2 = capacities of condensers

p, p_1, and p_2 = pressures on the condensers and P is total pressure across the condensers;

but $$\frac{q}{c} + \frac{q}{c_1} + \frac{q}{c_2} = P$$

If now C = equivalent capacity of the 3 condensers we know that $q = PC$.

but $$q = \frac{P}{\frac{1}{c} + \frac{1}{c_1} + \frac{1}{c_2}}$$

hence $$C = \frac{1}{\frac{1}{c} + \frac{1}{c_1} + \frac{1}{c_2}}$$

This simple case is worked out in detail to show the reader how to follow a typical case through. Many more cases might be stated but the preceding is sufficient to explain the underlying principle of the analogy.

The next analogy for consideration is the passage of current through a conductor. Many texts use the ordinary flow of current in a conductor, but it is a well known fact that the difference in head required to force a quantity of water through a pipe is

$$h' = \frac{f\,L\,V^2}{d\,2\,g}$$

This shows that the pressure difference between the ends of the pipe is proportional to the length, inversely proportional to the diameter and a function of the internal surface condition of the pipe. But the passage of the current in a conductor is a function of the length, an inverse function of the area and dependent upon the nature of the material. If now a pipe is filled with a porous substance the resistance to flow is a function of the length and porosity and an inverse function of the area. The example may be carried still further. The pipe itself becomes the insulation on the conductor and acts just as insulation would act. If the pressure on the pipe line is raised to a high value the pipe begins to leak. This is similar to corona loss on high voltage conductors. If the pressure is raised to a still higher value the pipe breaks, which is just what happens in insulation break-down phenomena. There is therefore nothing new in the ideas of electric current flowing in a wire.

We have seen the theory of the condenser and of the resistance to flow of current. A study of the nature of the flow of current is desirable in order to gain an idea of the inductance effects.

From the study of natural systems we know of no case of an independent organization other than a system of rotating bodies which in turn has rotation. It is therefore natural to assume that matter in its elemental state is made up of rotating bodies. The logical conclusion in connection with the passage of charges, which go to make up the current through a wire is, that they would be rotating systems. From the above it might well be expected that, as the charges pass through the wire, the paths of the individual charges will be helical in form.

Conceive now of a pipe in which water flows to be made of an elastic substance. As the water flows in a spiral course, a series of waves will be propagated along the pipe surface. If now, resorting to Maxwell's theory of rotating ether cells, the pipe is surrounded by a series of rings of spheres, like ball bearings, the analogy is most logical. These spheres are free to rotate both about their centers of gravity and about the axis of the pipe. The rings of spheres will be set in rotation both about their centers and the axis of the pipe by the surface waves of the pipe. This last motion is after the theories of Lord Kelvin and Larmon. The amplitude of the pipe waves will be a function of the impact forces on the pipe, due to the water in the pipe. Impact is a function of the quantity per sec. or current. Velocity of rotation is therefore a function of the current and the energy stored a function of the mass of the spheres and the square of the velocity or the square of the current.

The reader may ask why this apparent straining of the imagination to conceive of so odd a phenomenon and the writers can but say that it is the simplest analogy they have been able to get. For we know that the energy which is stored due to the inductance of a circuit is stored by virtue of the quantity flowing per second and is stored outside that quantity itself.

Now as the quantity of water per second is increased the speed of rotation of the pipe sphere rings is increased in direct proportion and the force required to cause the mass of the rings to be accelerated will be a function of the time rate of change of quantity

as $f = m\,a$

so, stated electrically $E = L\frac{di}{dt}$

It may also be shown that the energy stored in the rotating rings is $\frac{1}{2} L\, i^2$

In all of the preceding it is assumed that the friction due to the motion of the rings and pipe have been neglected.

It now becomes necessary to show that the inductance effect is increased by coiling the pipe. Consider that the space within the

coiled pipe is filled with spherical bodies. Then as the current flows around the coil the rings on the pipes are in motion and this motion is in turn transmitted to the spheres in the central coil space. It may be shown that, as the force action is a frictional force, there is an unbalanced force acting on the spheres setting them in rotation about the axis of the pipe. The greater the distance from the pipe the slower the velocity both of rotation and translation, due to one pipe ring. For as the distance increases the number of spheres to be set in motion increases with a slight decrease in the power available. At the center of the pipe turn, we will therefore have a force driving the center spheres which is due to all the pipe rings on that turn and therefore the velocity of the center spheres expressed

as $V = \frac{K\, 2\, \pi\, q}{R}$

where q is the quantity of water per second and R is the radius of the pipe turn. This is comparable to the expression for the intensity of the magnetic field at the center of a circular loop of wire carrying a current i which reads

$$H = \frac{2\, \pi\, i}{R}$$

By following this discussion to the mathematical conclusion we may prove that with n turns in the coil of pipe the velocity of the axial row of spheres is expressed as

$$V = \frac{k\, 4\, \pi\, n\, q}{l}$$

where all the quantities are as previously explained except l which is the axial length of the coil. To conclude the discussion of the magnetic field as compared to the sphere field it may be shown that by placing the spheres in a less viscous substance than air the velocity of the axial row of spheres will be

$$V = \frac{k\, 4\, Pi\, n\, a\, u}{l}$$

where u is a constant indicating the decrease in viscosity. This will lead us to see that the total sphere field is similar to the magnetic field and that the total value of the field which is expressed as Φ in the magnetic system may be expressed in the sphere system as $\Phi = N\, V$ where N is the number of spheres and V is the average velocity of the spheres.

We may therefore say with Maxwell that a magnetic field is made up of ether spheres in rotation; and therefore discard the idea of the magnetic field being a mass of stationary ether in tension or compression.

The next study must be that of voltage generation. If we take a length of the elastic pipe filled with water, as indicated in the pre-

vious discussions, surrounded by sphere rings and convey it through a field, the pressure difference between the ends of the pipe will be proportional to the length of the pipe, the velocity of the pipe and the strength of the field. To prove this. First set up a sphere field by means of a coiled pipe and consider that the extent of the field is sufficient to cause the intensity to be nearly uniform. This will mean that all the revolving spheres coming out at the end of the coil will be moving at the same velocity both rotational and translational. As the pipe is moved through this sphere field it will cause the paths of the field spheres to be bent by a side pressure. This will cause a greater pressure between pipe ring spheres and the moving spheres ahead of the pipe than between the ring and the spheres just passed. This unbalancing of the pressures will cause the pipe rings to revolve about the pipe. The motion of the sphere rings will transmit to the pipe surface waves which in turn will set up a pressure or a tendency for the water in the pipe to move, and if water is allowed to flow will impart to the water an equal impulse per unit of weight irrespective of quantity. But a careful analysis of the phenomenon will show that, as the water flows in the pipe it will cause reactive forces to act on the pipe surface which will tend to stop the rotation of the rings. It will then be necessary to use a greater force to push the pipe through the field at the same speed. This in turn will cause a greater bending of the paths of the field spheres and the whole field of armature reaction is before us.

Following the idea of generation of pressure must come the idea of commutation, or the idea of directing the flow. A little study will show that a reversal of the field sphere motion reverses the motion of water in the pipe. If then a rectangular loop of pipe is forced to rotate in a mechanical field one side of the loop will be moving in the opposite direction from the other and the pressures will be in opposition in space. But, because of the end connection of one side to the other, both sides will tend to cause the water in the pipe to circulate in the same direction. It will, however, be seen that as the coil moves through 180 deg. the direction of motion of the water in the loop will have reversed. The pressure will be a direct function of the motion perpendicular to the translation of the spheres, and will therefore follow the sine law. An open loop rotated in the sphere field is therefore an alternator. The pressure of the alternator may be increased by the use of several turns in place of one loop. The commutator is simply a device whereby several loops displace angularly from each other are connected so that as the various pressures are generated the loops are so connected as to cause the sum of the pressures in the different loops to remain constant with regard to some external piping system. If space and time permitted it might easily be shown how the hydraulic analogy may be made to show the commutation difficulties met as reactance voltage generation, sparking, etc.

There is now sufficient material at hand to study the complete theory of the transfer of energy from an engine to any receiver circuit.

With a set of three coils of pipe displaced mechanically 120 deg. from each other, but rotating about the same axis, in a sphere field set up by passing a uniform current through a pipe coil, 3 currents will be caused to flow from the 3 pipe coils, each current being a sine wave current. We might expect six pipe connections would be needed to lead the water to and from the 3 coils, but by connecting similar ends of the 3 coils together 3 lead pipes may be used. For 3 sine wave variations add up to 0. Or, to put it in a way more readily seen, at any instant the sum of two of the currents will just furnish the other.

It is seen however that with the best machine we cannot generate pressure of sufficiently great value to allow piping to any great distance. This is due to the fact that the pressure would burst any of the ordinary rotating coils if a value which would allow for transmission were used. This will be seen when it is realized that to transmit any great amount of power either large quantities of water at low pressures or small quantities at high pressures would have to be used to transmit energy. A little figuring will show that the quantity of water which must be piped to allow 10,000 H. P. to be transmitted 50 miles at 200 lbs. to the square inch would necessitate so large a pipe as to put it out of the question. However if pressures of 500,000 lbs. to the square inch are resorted to we might be able to transmit the power with a reasonably small bore pipe. The question therefore arises how the power may be converted from low pressure large quantity to high pressure small quantity.

The transformer is a device which will allow the needed conversion indicated above. Its principle is as follows:

Take a transformer made up of 3 coils of a few turns of large diameter elastic pipe and 3 coils of a large number of turns of small elastic pipe. Place these coils in pairs, a coil of large and a coil of small pipe, end for end, and immerse them in a substance less viscous than air. Connect 3 similar ends of the large pipe coils together and attach the free ends to the ends of the generator coils by slipping connections. If now the generator revolves, current will be sent out to the 3 transformer coils which will set the pipe rings in motion. It is plain that, as the motion of the pipe rings is a function of the quantity per second or current, the acceleration of the rings will be a function of the rate of change of the current. This acceleration of the rings will be attended by an acceleration of the whole sphere mass, and the force which must be applied at any instant to cause

this acceleration is therefore a force to cause the corresponding rate of change of current, or as

$$f = \text{Ma so } E = L \frac{di}{dt}$$

From the laws of harmonic functions it will therefore be seen that the force leads the current by a quarter period. The reaction force will therefore lag the current by a quarter period. A study of the action in the second coil will show, that, as the spheres in general, accelerate the pipe rings of this coil will have the same acceleration in the same direction. This will cause the elastic pipe to have waves propagated along it. But as the pipe of the first coil tended to and did turn the rings, here the rings will tend to turn the pipe i. e. will set up waves to the surface. If now the pipe is full of water the pipe will tend to advance along the outer surface of the water. As the pipe cannot do this the water will be set in rotation and forced backward. We can easily produce the same formulae as will be produced by the transformer. e. g. The voltage is proportional to the number of turns, or the pressure is proportional to the number of turns. It will appear that the pressure in the first or primary coil is that required to cause the acceleration in the first coil rings and the number of turns, while the pressure in the second is due to the acceleration of the pipe rings and the number of turns.

Or again, as the quantity of water moved per second in the second pipe increases the reaction on the pipe rings will increase. This will cause a decrease in the speed of the rings. This decrease in the pipe ring speed will cause successively a decrease in the field sphere speed and the primary pipe ring speed. This will decrease the acceleration of the primary pipe rings and will require less force to accelerate and thereby allow more water to be forced through the first or primary coil. This increased mass of water in the pipe then furnishes the necessary energy for the moving of the increased amount of water in the second coil.

Inspection of the transformer action will show the reader that, when the sphere velocity becomes constant, there is no tendency for the pipe rings to rotate about the second pipe coil. This is due to the fact that, with constant motion there is insufficient pressure between the field spheres and the ring spheres. Or, the impact forces between the current and the pipe rings in the primary coil are only sufficient to overcome the motion of the field spheres and not to cause pressure action.

The three pairs of coils will have the above action and by putting the large number of turns coil away from the generator the three phase system of transformation is obtained.

The three coils of the alternator may be so connected as to allow for the use of three pipes to carry water from the coils. The transformer coils may be connected to use the same action.

Having the pressure increased, the water goes out from the station in three small, but very thick walled pipes. As indicated in previous work the pipe is like the insulation of the wire and the thick pipe corresponds to large insulators and wide spacing of wires. The leakage of water through the pipe will correspond with the leakage currents over the surfaces of the insulators. The capacity of the line is due to the elasticity of the spheres in the field. This will require a current of water in the pipes which will compress the spheres and which will be forced to reverse as the spheres expand.

An increase in the pipe spacing as in the case of increased distance between wires will cause a greater sphere field between the pipes and thus increase the inductive effect of the line.

A study of opening and closing of valves in this hydraulic transmission system will give a very good idea of the transients on the transmission line. For example: it is easy to conceive of a line so constructed and of such dimensions and characteristics as will cause the pipes to burst due to a sudden closing of the valves. Upon reaching the receiver end of the line we may step the pressure down for use in motors and the following paragraphs will indicate the hydraulic analogies of these different machines.

The purpose of the following discussion is to outline briefly the general ideas of the application of sphere and pipe coil theory to the ideas of the operation of electrical machines. While only the briefest outline will be attempted, yet it is hoped that this will be sufficient to give a clear idea of the breadth of the analogy.

Synchronous Motor.

Conceive several pipe coils displaced by equal angles in space, the axes of the coils lying in the same plane. Pass an undirectional current through these coils so that the field spheres will have opposite translation, relative to the coils, in adjacent coils. On a frame free to rotate about an axis perpendicular to the plane of the coil axes, at the interesection of the axes, place rectangular coils of pipe so that the planes of the coils are parallel to the axis of the frame. Make the coils of such dimensions as will bring the side of a coil under one fixed coil when the other side is under an adjacent fixed coil. Pass an alternator current through the rotating coils.

With the preceding in mind it is easily seen that, in order to have continuous motion, it will be necessary to have the frame rotating at such a speed as will allow for the reversal of the current in the rotating coil during the time of passage from one fixed coil to the next. This will be seen when it is remembered that, should the rotating coils be stopped there would be alternate tendencies to move first in one and then in the other direction as the sphere rings round the moving coil reversed, thus causing a reversal of the force action.

From the preceding all the studies of armature reaction, the effects of power factor, etc., may be developed. We may also apply polyphase as well as single phase currents to the motor.

Induction Motor.

We have seen how the synchronous motor operates and the induction motor being simply a motor with alternating current in both field and armature, it follows naturally. In the induction motor of the hydraulic type there will be three fixed coils spaced 120 degrees apart and carrying current of sine wave nature differing in time phase by 120 degrees also. We see therefore that the field spheres in the space surrounded by the field coils will be acted upon by three forces and it is readily seen that the direction translation will be continually changing but the velocity will remain constant. This is then in effect the same as rotating one coil with a constant current in it. By placing a squirrel cage of pipe in this rotating field with the ends of the cage pipe headers, we see that alternating currents will be generated if the speed of rotation of the cage is different from the speed of rotation of the field.

Single Phase Series Motor.

This motor has been devised to give a heavy starting torque and must therefore be of a variable speed type. That is, it must be able at low speeds to give a high torque. We must therefore have the current in the rotating member reverse as well as the field so that the torque will be in the same direction. This is done with the slipping connection mentioned early in the paper as the commutator. Here we have fixed field coil carrying alternating current and the field spheres therefore have alternating translation. The current in the rotor reverses at the same instant as the current in the field because it is the same current. The slipping connection therefore simply keeps the current in the armature flowing right under the field coils to give rotation.

Direct Current Machinery.

Nothing has been said so far with regard to direct current motors but a sufficient number of examples have been outlined to show what is intended.

While the foregoing is necessarily brief and not sufficiently exact for final work, it must be remembered that it would be necessary to write several complete volumes to carry this to a final conclusion. It is felt, however, that the writers on electricity and magnetism should follow some such physical conceptions for the best interest of the student.

In conclusion, the writers wish to beg the readers to withhold judgment of these ideas for a period, in order that old ideas may be

put away and the new discussed. It is not easy to discard the theory of stationary stressed ether as flux. Nor is it easy to put away the notion of a line of force as some theory individual to magnetic action, only a mathematical fiction and supplant it by the ideas of velocity. But after months of study the writers find much help in the new ideas as they give physical phenomena easily seen which explain all of the common actions. Few of the students of engineering can easily accept things as true which they cannot explain. One of the greatest needs of the day is a system of education which will cause the student to think. There are a limited few who can reason in the abstract, but the technical school must deal with the every-day "horse sense" of the ordinary man. If then this paper will help the thinking, even though it do no other good, it has served its purpose for the writers, and they hand it on.

THOMAS S. CLARKSON

MEMORIAL COLLEGE OF TECHNOLOGY

Potsdam, N. Y.

A College of Engineering for the Training of Men.

This Institution was founded in 1895. It was chartered, March 19, 1896, by the Regents of the University of the State of New York, and opened its doors to students in September of the same year An amended charter was granted September 25, 1913.

The College is located at Potsdam, St. Lawrence County, N. Y., on the Rome, Watertown & Ogdensburg division of the New York Central Railroad. It may be reached from all points through the connections of this road in New York State and Canada.

For admission there is required a thorough four year high school preparation. The regular courses extend over four years and comprise instruction in language, literature and history, mathematics, the natural and economic sciences, engineering and technology. The instruction is largely taken in common, during the first two years, and provides the elements of a liberal education Based upon similar instruction in the fundamental principles of the applied sciences, the subsequent training aims to develop the habit of clear and accurate thinking, familiarizing the student with the practical methods of executing work and projects and scientific methods of conducting investigations.

The four year courses in engineering afford thorough preparation for those who intend to engage in the professions of chemical, civil, electrical, or mechanical engineering. They lead to the degree of Bachelor of Science in the major subject pursued; namely, chemical, civil, electrical, and mechanical engineering. Post graduate degrees may also be given for work done in addition to the four year courses.

This College is included by the United States Civil Service Commission in the list of approved technical schools, diploma from which entitles the holder to promotion in the Engineer Department at Large; and in the list of accepted institutions entitled to share in the benefits of the Carnegie Foundation for the Advancement of Teaching.